

Appendix A

Implementation Plan for the Mid-Columbia River/ Lake Roosevelt TDG Total Maximum Daily Load: Summary Implementation Strategy

Overview

The goal of the total dissolved gas (TDG) total maximum daily load (TMDL) for the Mid-Columbia River is to establish load allocations for spill water and mixed river water that would enable the river to meet the water quality standards for TDG established by the Spokane Tribe, the Confederated Tribes of the Colville Reservation and the state of Washington. Water quality standards establish water quality goals that ensure water is healthy for such uses as irrigation, drinking water, and recreation in and on the water, and, in this case, the most sensitive use, anadromous salmonids habitat. Some of the anadromous species use the river for spawning and rearing, and anadromous fish use the river for migrating downstream as juveniles and returning upstream as adults. The portion of the mid-Columbia River addressed in this Summary Implementation Strategy (SIS) consists of the Columbia River upstream of the mouth of the Snake River to the United States border with Canada. This portion includes Lake Franklin D. Roosevelt and the other reservoirs.

This SIS, which will be issued concurrently with the TMDL, includes an initial list of actions for improving TDG at the dams. However, many of these actions are studies to clarify issues, address environmental impacts, determine feasibility, design improvement measures, or quantify the benefits of improvement measures. So the list of improvement actions, which constitutes the initial implementation plan, will change as studies are finalized, decisions are made, and funding is secured. The implementation planning will therefore be dynamic. The process and activities described in the SIS may be revised in the future. This SIS, for example, will be superseded by the outcome of a Clean Water Act Section 401 certification process that will take place as each public utility district (PUD) hydroproject applies for relicensing by the Federal Energy Regulatory Commission (FERC).

It describes the basic framework for future regulatory activities that control TDG generation. A series of water quality regulatory actions are anticipated for hydroprojects in the Mid-Columbia River. The primary action that will govern TDG control is the Clean Water Act Section 401 Certification (401 Certification) for each PUD project and gas abatement planning for the federal dams if the federal dams are successful in controlling TDG to meet the load allocations of the TMDL based on juvenile fish passage. Gas abatement planning will continue to be a tool used prior to and subsequent to a 401 Certification. A Detailed Implementation Plan for this TMDL will be issued in the future and refer to the 401 Certification process for PUDs and update activities at all projects that are improving control of gas generation.

Gas generation and reduction at the Columbia and Snake River dams has been the subject of intensive research over the past few years. Federal fish agencies, tribes, Canadian agencies, the U.S. Environmental Protection Agency (EPA), Bonneville Power Administration (BPA), the PUDs that operate the Mid-Columbia River dams, state fish and wildlife departments, the Bureau of Reclamation (BOR), and the U.S. Army Corps of Engineers (Corps) are organized into work groups to address the TDG problems. The result of this is a much enhanced understanding of the generation and dynamics of TDG production. In addition, implementation actions designed to reduce TDG generation have already been undertaken.

Sources outside of the mainstem, including tributaries, are not included in this TMDL and will be addressed individually in other actions. The geographic scope of the TMDL is limited to the Columbia River upstream of the Snake River confluence within the boundaries of the United States and thus excludes Canadian waters.

The development and implementation of feasible TDG improvement measures at the dams will require studies, time, and resources. Determination of the feasible operational or structural modification alternatives will also require the cooperation and coordination of dam operators, states, and Indian tribes responsible for TMDL implementation, and the federal agencies that implement the Endangered Species Act (ESA).

The dams on the river pass water by spilling over the spillway, by generating electricity through the turbines, and to a much lesser extent by passing water through special fish facilities such as adult ladders and juvenile fish passageways. TDG is generated by spilling water over the spillway. Absent considerations for fish survival, spills are considered “involuntary” since they occur due to lack of powerhouse capacity. Involuntary spills can be caused by flood flows, lack of electric load for powerhouse generation, or turbines being off-line due to maintenance or repair. However, fish survival needs necessitate spills to improve juvenile fish passage.

Convergence with the Columbia River Biological Opinions

At the Mid-Columbia River projects, as well as at other hydroelectric projects in the Columbia Basin, spill is typically a relatively benign route for juvenile salmonids to pass the dams (Chapman et al., 1994a, 1994b). For this reason, voluntary spill for juvenile fish passage or use of spillway-based juvenile bypass systems is currently employed at each of the five hydroelectric projects operated by Douglas, Chelan and Grant PUDs. However, spill may result in supersaturated levels of TDG. The Mid-Columbia PUDs limit voluntary spillway discharge and use of spillway-based bypass systems during the fish passage season to ensure that TDG does not exceed an average of 120% of saturation in project tailraces or an average of 115% of saturation in project forebays for any 12 hour period, or as otherwise ordered by TDG special condition requirements issued by the Washington Department of Ecology (Ecology).

Up to a point, the danger to fish from exposure to high TDG is overshadowed by the dangers to fish of going through the turbines. In response, the National Marine Fisheries Service (NOAA Fisheries) performed a comparison risk analysis that forms the basis for modifications to Washington’s water quality standard for TDG. Biological monitoring has been required by the

state of Washington in order to assess gas bubble trauma to fish as a result of spill. Based on six years of data, little trauma to migrating juvenile salmon at the special fish passage TDG levels has been seen at the fish monitoring stations.

In December 2000, NOAA Fisheries released a Biological Opinion (BiOp) for the Federal Columbia River Power System (FCRPS) under the federal ESA for 12 listed species in the Columbia and Snake rivers. A significant component of this BiOp is the provision of spilled water at the Mid-Columbia River hydropower facilities to facilitate fish passage. BiOps for PUDs Habitat Conservation Plans (HCPs) also have provisions for fish passage by spill up to TDG levels of 120%/115% or other means. Clearly, if spilled water is the cause of elevated TDG levels but is required for fish passage, care needs to be taken not to implement gas abatement measures that may benefit water quality, while damaging the beneficial uses, such as juvenile migration, that the federal Clean Water Act was enacted to protect.

Habitat Conservation Plans (HCPs) have been filed that specify mitigation measures for anadromous fish passage in the Mid Columbia River. Measures that promote fish passage survivability include spills and modified spills that generate TDG during the outmigration of juvenile fish.

The HCPs for the Douglas PUD and Chelan PUD dams states that they will control TDG levels under total river flows up to the 7Q10 peak flow event to 120% of saturation. This level, higher than the normal 110% criteria state standard, is a result of the need to increase TDG beyond the criteria in order to promote juvenile fish passage. The criteria are adjusted upward during the fish passage season through the gas abatement plan process.

This implementation strategy therefore must take into account both requirements: to reduce high TDG generated at the dams by spilling water, and to provide the levels of spill under the BiOps to facilitate fish passage.

Participants and Management Roles

The governmental agencies responsible for dam operation or hydropower management, state federal and tribal agencies that have implementing authority or an interest in improving TDG in the mainstem all participate in the development of alternatives for system and individual dam operation.

The operation of the Columbia River hydropower system is carried out through multiple agencies and governed by several regulatory authorities. The following is a list of these parties:

- The U.S. Army Corps of Engineers (Corps) operates Chief Joseph dam and provides engineering, contracting and construction authorities (based on funding from Congress) for structural changes. The Corps provides flood control oversight and responds to the energy, environmental, transportation, and recreational needs of the public. The Corps is required to achieve a balance between these requirements where they conflict.
- The Bureau of Reclamation (BOR) operates Grand Coulee dam and provides engineering, contracting and construction authorities (based on funding from Congress) for structural

changes. The Columbia Basin Project is operated by the BOR to provide power generation, irrigation, flood control, recreation, and fisheries.

- NOAA Fisheries and the U.S. Fish and Wildlife Service oversee the protection of endangered species. Several forums have been established to oversee implementation of the Biological Opinion requirements for these species. These forums include the Water Quality Team that focuses on temperature and TDG management, the Technical Management Team that makes decisions regarding hydropower operations, the System Configuration Team that makes decisions on structural modifications, and an implementation or policy team to which policy issues that cannot be resolved in the other forums are elevated.
- Tribes have treaty rights to the salmon and are involved on many levels of fish management and environmental protection. The Yakama Nation, the Confederated Tribes of the Umatilla, the Nez Perce Tribe, and the Confederated Tribes of the Warm Springs Reservation all have treaty rights along various parts of the river. The Spokane Tribe and the Colville Confederated Tribes have harvest rights and have approved water quality standards for portions of the Columbia River bordering each reservation.
- The Bonneville Power Administration (BPA) oversees power production and distribution. Revenues help fund partial fish and environmental mitigation for the impact of the dams.
- The Washington Department of Fish & Wildlife works within the forums detailed above, as well as protects and enhances non-listed salmon, resident fish, and wildlife.
- The U.S. Environmental Protection Agency (EPA) is part of the caucus of federal agencies involved in operation and management of the federal Columbia River hydropower system. Its specific role is to ensure consistency with federal environmental laws and regulations. Regarding the Canadian water use planning and hydropower licensing process, EPA will work with the state to seek a mechanism so that applicable downstream standards are met at the international border. The agency will ultimately take action on this TMDL under Section 303(d) of the federal Clean Water Act (CWA).
- The Mid-Columbia PUDs own and operate the mid Columbia run of the river dams for publicly owned power generation. Through operating licenses granted by the federal government, other duties such as protecting fisheries resources and meeting water quality criteria are required.
- The Washington State Department of Ecology (Ecology) will oversee implementation of this TDG TMDL. They will work collaboratively with the U.S. Army Corps of Engineers, BPA, tribal, and other state and federal agencies through existing forums. Tools available include interagency agreements, administrative orders, 401 Certifications as part of FERC relicensing, and gas abatement plan approvals required by surface water quality standards.
- Other agencies are involved in different aspects of river management that can have a bearing on TDG generation. The most prominent include the Northwest Power Planning Council, data gatherers such as the Fish Passage Center and U.S. Geological Survey, and the states of Idaho and Oregon.

Implementation Plan

Meeting the load allocations in this TMDL will fall into two phases. Short term Phase I will involve improving water quality, while ensuring that salmonid passage is fully protected in accordance with the BiOps, HCPs and FERC license conditions. Potential long term Phase II may involve structural and operational changes to dams to achieve the water quality standard for TDG.

The short-term actions in Phase I will focus on meeting fish passage performance standards as outlined in the 2000 FCRPS BiOp through spills that generate gas within the fish passage levels of the water quality TDG standards (Washington special conditions).

A Detailed Implementation Plan (DIP) or equivalent will be developed that further refines the measures to be considered in Phase II. The DIP is planned to be issued after EPA approval of the TMDL. The DIP will explain the progress towards meeting the load allocations, any revisions to the monitoring strategy, and present any new information that could affect how the TMDL is implemented.

Phase II will evaluate success from the short-term actions. The second phase may require further structural modifications and reductions in fish passage spill if the Biological Opinion specified performance standards are being met and adequate survival is provided for non-listed species.

The Corps published its Final Draft Technical Report and Appendices of the Phase II Dissolved Gas Abatement Study (DGAS) in April 2001. Measures that are considered in DGAS may be applicable for other nonfederal dams. Chelan, Douglas and Grant Public Utility Districts have studied gas abatement efforts at their dams and have written their current studies and improvement options in gas abatement plans. Both the Corps and the PUD plans have been submitted periodically to Ecology for approval. These studies were undertaken as part of the Columbia River Fish Mitigation Program. The studies have been the result of an ongoing collaborative effort between federal and state fisheries agencies, dam operators, tribes, and environmental agencies toward reducing TDG in the river in balance with enhancing spill opportunities for juvenile salmon. Implementation of operational alternatives, additional or modified spillway flow deflectors, and powerhouse/spillway flow separation walls has the potential to significantly reduce production of TDG and can be implemented in the near term at dams where this is necessary to meet TDG criteria..

Implementation Activities

Short Term – Phase I

This phase is already underway, as a result of actions taken by the Corps, the BO R, Douglas County PUD, Chelan County PUD, and Grant County PUD No. 2 and will continue through 2010. The emphasis in this phase will be taking actions that result in reductions of TDG, while ensuring the fish passage requirements of the the BiOps and FERC license conditions are met. The BiOps envisions spill for fish passage under modified water quality criteria of Washington,

as provided for the past few years. Maintenance of required spill at the modified standards to allow for fish passage will be measured at the fixed monitoring stations both in the forebay and the tailrace of each dam.

Several operational implementation actions are being used to minimize involuntary spill or can be evaluated during Phase I and implemented if practical. These include:

- Scheduling routine turbine maintenance and repair during low-power load and river flow periods.
- Preventive maintenance of turbines to prevent breakdown.
- System management of water release from upstream storage reservoirs to minimize involuntary spills at dams in the TMDL area.
- Optimizing power purchasing to allow maximum use of powerhouse capacity and minimization of involuntary spill.

Changing the way a hydroproject is operated (in addition to modifying total volume of spill) can also have impacts to the amount of TDG produced below a dam or a series of dams. Three examples of operational changes that can be instituted include:

- Changing of spill patterns at individual hydroprojects,
- Shifting of power production between dams,
- Spill prioritization at projects.

Some initial short term actions were specified as part of the Reasonable and Prudent Alternative (RPA) in the National Marine Fisheries Service's BiOp on the operation of the Federal Columbia River Power System (FCRPS) (December 2000) prepared under the federal Endangered Species Act for 12 listed species in the Columbia and Snake Rivers (Table A-1). Other measures were developed through the gas abatement plans in effect at the PUD operations (Table A-2). The activities and studies for improving river TDG are already in place due to the BiOp and gas abatement plans and constitute the core of short term actions to contribute to ongoing compliance with the CWA. The short term actions will be completed or in progress prior to 2006.

The BiOp also contains Appendix B "Development of a Water Quality Plan for the Columbia River Mainstem: a Federal Agency Proposal." The water quality plan called for in the document can be found at <http://www.nww.usace.army.mil/reports/waterquality/wqp2003.pdf> The "Water Quality Plan for Total Dissolved Gas and Water Temperature in the Mainstem Columbia and Snake Rivers" was a collaborative effort of federal agencies, state, and tribes. The plan identified the BiOp actions, potential additional actions, and studies that should be conducted to clarify issues, design improvement measures, or quantify the benefits of improvement measures.

Table A-1 describes each action, the reference to both the BiOp and the Water Quality Plan for TDG in the Mid-Columbia River, and the current status of those actions.

Table A-1: Initial Short-term Interim Implementation Activities for Federal Projects

Action Item Description	Responsibility	Biological Opinion Action Item #	Mainstem Water Quality Plan Action Item #	Status
Complete systemwide gas abatement study	Corps	130	S-1	completed
Chief Joseph :Gas fast track; spillway deflector design and installation	Corps	136	M-2	Funded for final design
Grand Coulee: Gas abatement study; evaluate GCL-CHJ gas abatement	Corps/BOR	136	R-2	In progress
Systemwide: TDG monitoring program	Corps	131	R-1	ongoing
Systemwide: Evaluate fixed forebay TDG monitors to determine best location	Corps	132	M-3A	In progress
Develop system dissolved gas model	Corps	133	R-7	In progress
Evaluate gas entrainment divider walls at FCRPS mainstem projects	Corps	135	S-2a	completed

Short term actions proposed by the nonfederal dams through voluntary compliance schedules submitted in gas abatement plans and draft 401 certification documents and the current status of those actions are listed in Table A-2.

Table A-2: Initial Short-term Interim Implementation Activities for non-federal projects

Action	Responsibility	Where proposed	Status
Chelan PUD contract literature review	Chelan PUD	Gas Abatement Plan	In progress
Chelan PUD submerged spill modeling	Chelan PUD	Gas Abatement Plan	Completed
Douglas PUD Contract Gas Abatement Study	Douglas PUD	Gas Abatement Plan	In progress
Douglas PUD develop Operational Spill Plan	Douglas PUD	Gas Abatement Plan	In progress
Grant PUD install spill deflectors at Wanapum Dam	Grant PUD	Gas Abatement Plan	Completed
Grant PUD evaluate and implement placement of advanced turbines	Grant PUD	Water Quality Management Plan	Begin in 2005

Flow/Spill Coordination

The six dams below Grand Coulee Dam on the Mid-Columbia are run-of-the-river dams with very little storage capacity. Therefore, high releases at Grand Coulee Dam can force spill at downstream hydropower facilities.

The Mid-Columbia Hourly Coordination Agreement was first signed by the BOR, Corps, BPA, and the Mid-Columbia PUDs in July, 1972, to minimize these operational spills. The Mid-Columbia Coordinating Group matches power needs and water supplies at both Federal and Non-Federal hydropower facilities on a system wide basis.

Spill Priorities are established by the Corps with water quality in mind. Generation Scheduling adjusts generation throughout the FCRPS to make sure spill occurs according to these guidelines (distribution among projects, amount, and timing). (Unless the inflow to Grand Coulee Dam exceeds its turbine capability when the project is full, spill there should only occur according to the Corps' guidelines.)

One of the purposes of Hourly Coordination is to reduce the amount of unwanted spill on the 7-Project system. However, after reducing the amount of spill that would have otherwise occurred, the distribution of any remaining spill at non-Federal projects is managed by the Central (Grant PUD) Dispatcher. Spill is managed in accordance with Spill Priority guidelines furnished by the Corps.

Power Load Redistribution

Because power generation and spill have different TDG production potential at various dams, using operational changes at a combination of dams may also help to decrease TDG system wide. For example, at Chief Joseph and Grand Coulee dams, studies have indicated that because passing water through turbines at Grand Coulee adds little to no gas to the water, and that spill at Grand Coulee usually generates far more TDG than equal spill at Chief Joseph, full turbine operation at Coulee combined with spill at Chief Joseph could have more TDG benefits system wide rather than both spilling water and generating power at each dam.

Fish Passage Improvement

The BiOp requires that certain performance objectives be met. Currently many agencies prefer the spillway as a non-turbine passage route for fish, despite the generation of higher than preferred levels of TDG. Any improvements to fish passage systems, including more fish diverted from turbines by more effective traveling or bar screens, would help to reduce the reliance on spill as a non-turbine passage route. This in turn could reduce the amount of TDG in the system.

A Removable Spillway Weir (RSW) is an overflow weir that can be installed in a regular spillbay at dams. The weir is elevated from the typical spillway ogee, thereby creating a surface draw from the forebay rather than the deep draw conditions of most existing spill operations. This device is meant to pass a high percentage of surface-oriented fish in a relatively small amount of water and is currently being tested at Lower Granite Dam to determine if it will enhance juvenile salmonid passage at this location and potentially at other dams. During high flow conditions, approaching standard project flood levels, the weir can be lowered out of position down to the river bottom whereby the dam can pass unimpeded the standard project flood flow. RSWs are a means to provide or maintain levels of fish passage while possibly reducing the volume of voluntary spills.

Additional measures designed to pass juvenile fish via improved screened bypass or alternative surface bypass systems at powerhouses may also provide a reduction in TDG. If fish can be successfully passed via a non-turbine route other than spill then it may provide an opportunity to reduce the reliance on voluntary spill as a means of juvenile salmon passage and in turn could have a beneficial effect on TDG. The flow net concept has been implemented at Wells and Rock Island Dams through the modified spill-based bypass systems. Surface collector juvenile fish bypass systems are in place at Rocky Reach Dam and have been tested at Wanapum Dam.

Actions by Each Hydroproject

The operators of the hydroprojects on the Mid Columbia River have taken and proposed actions that are intended to control TDG generation. This section outlines the actions based on information supplied by the project operators.

Grand Coulee Dam

Supersaturated TDG is generated at Grand Coulee Dam when a portion of the total discharge is spilled through the outlet tubes or drum gates. Involuntary spill occurs an average of one in every six years at this dam. Because power plant releases transfer forebay gas levels downstream to the tailrace without introduction of additional dissolved gas, the 280,000 cfs (cubic feet/second) hydraulic capacity of power generation facilities provides an opportunity to resolve at least a portion of the TDG problem at Grand Coulee operationally, if adequate load can be developed or transferred there, for example, from Chief Joseph Dam.

The BOR completed the “Structural Alternatives for TDG Abatement at Grand Coulee Dam” in October 2000. The study of gas abatement options at Grand Coulee Dam was conducted on a parallel track with Corps studies of Chief Joseph Dam spillway deflectors. The study evaluated gas abatement effects in the Grand Coulee tailrace with and without transfer of power loads from Chief Joseph to Grand Coulee. Results of the BOR study indicated that the ability to reach 110% TDG in the mixed river below Grand Coulee is more dependent on the TDG levels present in the reservoir above than on any of the structural or operational changes studied. However, a potential structural gas abatement option at Grand Coulee could include extending and covering the existing outlet tubes to provide for submerged discharge of spill.

Following completion of the structural gas abatement study, the BOR requested formation of a System Configuration Team/Water Quality Team subcommittee. The committee would evaluate the Chief Joseph and Grand Coulee joint operations alternative for transferring power loads to Grand Coulee, evaluate load growth between 1997 and 2005, and project the estimated proportion of the seven day, ten year (7Q10) flow which could be used for power generation at Grand Coulee during future flood control operations. Based on the results of this study, the subcommittee concluded that for flow up to the 7Q10 value, the risk of spill at Grand Coulee could be effectively eliminated by joint operations between the two projects, involving shifting of power generation to Grand Coulee. The resulting flow increase from Grand Coulee would require spill at Chief Joseph Dam after construction of spillway flow deflectors.

Chief Joseph Dam

The TMDL places a load allocation based on the 110% criterion on spill discharge of Chief Joseph dam. Although Washington State standards include the provision to authorize higher TDG levels to promote juvenile fish passage, the Colville Tribal standards do not include such a permanent provision. The Colville Confederated Tribes may grant a waiver of the 110% standard if the Corps demonstrates reasonable progress in achieving the standard. The rate of spill at Chief Joseph Dam has declined over the last few years and work is proceeding to reduce gas generation during spill events. Flow deflectors that enable compliance with the 110% criterion are expected to be functioning prior to the conclusion of phase I.

The BiOp required the Corps and BOR to individually and jointly examine gas abatement opportunities at Chief Joseph and Grand Coulee dams. The Corps initiated a planning study for Chief Joseph Dam in several phases and produced several documents that can be found on the Web: <http://www.nwd-wc.usace.army.mil/nws/hh/gas/index.html>. Similarly, the BOR began an evaluation of alternatives for Grand Coulee.

The System Configuration Team (SCT) participated in a screening process to select three alternatives. The preferred alternative was to install flow deflectors at Chief Joseph Dam and to operate it jointly with Grand Coulee. Joint operation would entail a shifting of spill from Grand Coulee to Chief Joseph and a shifting of generation in the opposite direction.

The 2000 Biological Opinion RPA Action Item 136 requires the Corps to develop and construct spillway deflectors at Chief Joseph Dam by 2004 to minimize total dissolved gas (TDG) levels associated with system spill. Additionally, RPA 136 instructed the Corps, Bureau of Reclamation and the BPA, to the extent feasible, to operate Grand Coulee and Chief Joseph dams jointly to reduce the incidence of spill and TDG supersaturation below Grand Coulee by spilling proportionately at Chief Joseph and shifting electrical load to Grand Coulee Dam. This arrangement has an overall benefit to mixed river TDG because it avoids spill at Grand Coulee which in most cases, adds more TDG than equivalent volumes of spill at Chief Joseph Dam.

In April 2000 the Seattle District of the Corps completed a General Reevaluation Report on the Chief Joseph Dam Gas Abatement Study. The preferred alternative was to design and construct spillway deflectors at the project and to operate Chief Joseph jointly with Grand Coulee.

The Corps received an additional \$500,000 of congressional funds to initiate design in FY03 of the flow deflectors selected during the General Reevaluation Report process as well as complete the design of some pre-construction projects necessary for dam preparation prior to the construction of the flow deflectors. The Corps will continue to seek appropriations to develop and construct the spillway deflectors at Chief Joseph Dam.

Wells Dam

Douglas County PUD has submitted gas abatement plans to Ecology in support of securing the special fish passage permission to discharge up to 120% TDG in the tailwater of Wells Dam and up to 115% in the forebay of the next downstream dam, Rocky Reach. Activities to improve

TDG levels are described in the Gas Abatement Plans. A gas abatement study is in progress and an operational spill plan development is in progress.

The gas abatement plan approvals will continue to be required by Ecology for fish spill flows that exceed 110% TDG. Douglas PUD will continue to study operational and structural ways to reduce TDG to within water quality standards.

Douglas PUD will continue to participate in the regional water quality team and trans-boundary gas group forums in coordination with the other Mid-Columbia PUDs

Rock Island and Rocky Reach Dams

Chelan County PUD also submits gas abatement plans for its two dams. Submerged spill modeling to reduce TDG levels and a literature review of other potential measures are described in the 2003 spill season gas abatement plan.

The gas abatement plan approvals will continue to be required by Ecology for fish spill flows that exceed 110% TDG. The fish passage bypass facilities being currently installed will be evaluated for capacity to reduce voluntary spill in tandem with improved fish survival after fish passage efficiencies are achieved with the bypass. The utility will likely need to pursue hydraulic studies through physical and computer models and on-site studies for long-term structural modifications.

Presently, it is anticipated that a combination of spill deflectors, submerged spill, operational conditions, and variation of the total amount of spill will yield the best results in terms of a balance of TDG abatement and juvenile fish passage. Additional testing and investigation of these options is needed to select an appropriate combination.

The permanent fish bypass system at Rocky Reach Dam began operation in the spring of 2003. Testing completed during this first year of operation assisted the PUD in determining the guidance efficiency of the permanent fish bypass system. The most efficient use of voluntary fish survival spill at Rocky Reach will be to supplement the effectiveness of the fish bypass system, when needed, to reach survival goals of the HCP. High fish survival may, in future years, result in reductions of voluntary spill if survival and behavioral studies demonstrate that less spill is needed to meet survival standards.

Over the course of the next two years, the PUD will investigate the feasibility and potential benefits of modifying the depth of the stilling basin and structure of dentates/baffle blocks in the stilling basin. If such modification is determined to be feasible and likely to provide a total dissolved gas benefit, while meeting HCP survival standards, the PUD will evaluate the potential of such modifications to significantly improve water quality and the biological benefits that could result. If this analysis shows significant benefits commensurate with the potential economic burden, the PUD will begin the modeling process. If modeling and analysis are favorable, the PUD may commence modification and testing of one dentate as a prototype.

The PUD has made no structural changes to Rock Island Dam since the installation of the prototype deflectors in Bays 16 and 29. The deflectors were used during 2003 and will be used again during the 2004 fish spill season to take advantage of their TDG abatement characteristics

One physical modification the PUD is currently developing is the concept of over/under spill. This spill configuration will employ a spillway with both an upstream gate and a downstream gate. The upstream gate, likely a surface spill notched gate, will be opened at the surface, potentially attracting fish. The downstream gate will be lifted from the bottom, resulting in submerged spill, which the 1999 WES study showed eliminated gas entrainment since no air could mix with spillway flows. The desired outcome of this configuration is to achieve a high level of fish passage and survival through the notched gate while maintaining a submerged spill condition under the downstream gate. A consultant hired by the PUD is currently analyzing this design.

If the initial evaluations of the over/under design are favorable, the PUD will contract with Iowa Institute of Hydraulic Research to perform testing on a 1:20 scale model previously used for the Rock Island Dam deflector evaluations.

If analysis and modeling are favorable, construction of the new over/under configuration may begin after 2004 fish spill, with completion in November.

Another physical modification under consideration is an increase in the number of spill gates that are capable of providing submerged spill. The conceptual design of gate support structures and consideration of how additional submerged spill could be compatible with fish survival objectives is planned for 2004. If a favorable design is found and it is determined that submerged spill is conceptually compatible with fish survival, evaluation of fish guidance will occur following the completion of Phase I of the HCP (2007). If the results of the guidance evaluation are positive, evaluation of fish survival through a single submerged gate will be conducted. If the results of such testing are compatible with the PUD's survival goals, installation of additional gate support structures will begin.

Wanapum and Priest Rapids Dams

Grant PUD will manage spill volumes to aid fish passage to within the TDG criteria subject to hydraulic conditions, total river flow, construction activity, maintenance requirements or emergency conditions. Grant PUD will coordinate the spill program with the spill activities of other projects through the Coordinating Committee or its successor.

Grant PUD will seek to coordinate spill and energy replacement spill transactions in accordance with the priorities established by the federal Technical Management Team (TMT) to balance TDG levels throughout the basin as may be warranted by the conditions at the time.

Grant PUD may continue to identify and implement experimental spill regimes as may be warranted to test opportunities for improving survivals with less spill and/or reducing TDG levels at either Priest Rapids or Wanapum Dams. These experiments will be designed, implemented and evaluated in consultation with the Coordinating Committee.

Grant PUD will continue to participate in the regional Water Quality Team and Transboundary Gas Group in coordination with the other Mid-Columbia PUDs.

Deflectors were installed at Wanapum Dam as provided in the TDG Abatement Plan approved in April 2000. Grant PUD will be pursuing measures to reduce reliance on tainter spill to aid fish passage. When spill is required, however, Grant PUD plans to continue to operate each tainter gate with flow deflectors during the next license term.

The turbines at Wanapum Dam are approaching the end of their useful life and require replacement. Both Grant PUD and NOAA Fisheries are of the opinion that proposed new turbines will be able to significantly improve the survival of migrating juvenile salmon. For this reason, Grant PUD and NOAA Fisheries expect that a BiOp will be issued in the near future that supports installation of Advanced Turbines at Wanapum Dam so that a greater percentage of such migrating fish would be able to safely pass through these turbines. It is anticipated that Grant PUD will be able to provide improved survival with all ten advanced turbine units in operation resulting in less fish spill at Wanapum Dam. It is anticipated from early model runs, that the new turbines will increase hydraulic capacity up to 188 kcfs at 75 feet of net head at the cavitation limit with existing generators. This will result in the elimination of many periods of forced spill, reduced fish spill, fewer turbine unit outages and a corresponding decrease in TDG. Grant PUD intends to proceed with installation of one advanced turbine unit at Wanapum Dam in 2004 - 2005 and, if the testing meets predefined performance criteria as set forth in its application to FERC, proceed according to FERC approval to install the remaining nine turbines between 2006 and 2012.

In addition to the use of spillway deflectors, additional bypass flows through future unit bay 11 at Wanapum Dam will provide an additional 20 kcfs of flow with a submerged chute downstream widening at the end to approximately 90 feet. The spreading spillway will allow the energy in the bypass discharge to dissipate.

In addition to enhancing fish survival, a primary benefit of the measures is that they each contribute to attainment of the criteria for TDG. The Advanced Turbines hydraulic capacity is estimated to increase from approximately 160 kcfs to 188 kcfs with existing generators. This means that the spill volume between hydraulic capacity and the 7Q10 flow of 264 kcfs for Wanapum Dam reduces by 28 kcfs.

Grant PUD plans to develop a new passage measure for Wanapum Dam that would replace the current fish spill program with a 20 kcfs surface spill design located adjacent to the powerhouse. In addition this proposal included tailrace features specifically designed to reduce TDG levels by preventing the spill from plunging into the tailrace and instead creating a surface skimming flow. Construction of tailrace features includes extending a submerged chute downstream and widening the discharge end to approximately 90-feet. The spreading spillway will allow the turbulent energy in bypass discharge to be reduced significantly thereby minimizing negative tailrace effects.

Grant PUD conducted a detailed analysis evaluating various downstream fish passage alternatives for Priest Rapids Project (Voskuilen et al. 2003). The design for Priest Rapids fish bypass at Spillbay 22 consists of constructing a new intermediate pier in Spillbay 22 and future tailrace enhancements, with a combined flow of 40,000 cfs. The key feature of the proposed Priest Rapids bypass is the downstream feature of an extended stilling basin with training walls

to produce a surface skimming flow that would prevent the 40 kcfs of surface spill from plunging to depth.

Similar to the situation at Wanapum Dam, new turbines at Priest Rapids Dam would also increase hydraulic capacity, which will eliminate many periods of forced spill.

Long Term – Phase II

This phase will begin in 2011 and proceed through 2020. The Biological Opinion survival goals should be met through fish passage actions other than spilling water that results in TDG levels over the criteria. Reductions in gas entrainment through spill will be realized so that the required final goal of meeting the water quality standard for TDG can be met as measured at the end of the aerated zone below each dam.

Long term actions will require years to develop and implement. The federal actions will also undergo study and public process under the National Environmental Policy Act. Potential implementation actions shall be evaluated in context with other legal and social impacts. The other uses of the mainstem rivers, impacts on hydropower production, irrigation, navigation, fisheries, cultural resources and recreation will be evaluated during this process.

Most potential long-term actions require further study but include structural alterations and implementation of operational changes to dams to promote fish passage and reduce TDG in the rivers. The exact level of improvement possible from different operations or structural modifications at the dams is not known at this time. Once this information is available, it can be determined whether the level of improvement at the dams called for by the TMDL is achievable through the implementation of reasonable measures. At that point, if the water quality criteria are not attained, amendment of the water quality standards through the process outlined in the federal regulations at 40 CFR Part 131 may be appropriate.

Most federal studies and associated implementation measures require funding approval and may require congressional authorization. These studies may be conducted in concert with ESA consultation(s). Potential Long-term Implementation Activities are listed below.

Potential Long-term Implementation Activities

- Additional transboundary gas abatement efforts with Canada
- System-wide reduction of TDG entrainment in turbine outflows
- Mid-Columbia PUD gas abatement
- Alteration of the flood flow control curves
- Development of increased power market to take advantage of off peak turbine capacity

System-wide operational strategies may be developed when the options available to improve TDG are better understood. The strategy of reducing TDG levels in the Columbia River by trading power revenues from decreased spills is an example of a system-wide strategy.

The Corps DGAS study identified a number of structural measures designed to abate TDG. Several of these measures should be evaluated for their efficacy in abating gas and ensuring that

they provide safe and effective fish passage. If necessary, those measures found to be effective and safe should be identified for funding and implementation.

Alternatives that are considered more long term since they will require regional consensus, possible prototype studies, lengthy engineering studies, lengthy construction periods, very high implementation costs, and have uncertainty as a safe bypass route for fish may include:

- Raised tailrace channel
- Additional spillway bays
- Submerged conduits
- Baffled chute spillways
- Side channel spillways
- Pool and weir spillways
- Submerged spillway gates
- Increased power generation, less spill
- Deflectors
- Submerged empty turbine unit spill
- Further fish bypass systems
- Further power trading
- Further regional coordination for Grand Coulee releases

Making physical changes to the hydroprojects typically means constructing more physical structures in the river at the dams. Examples of structural changes to the dams that have either been made or proposed in recent years include installation of advanced turbines, spillway flow deflectors, additional spillbays at existing dams, removable spillway weirs, and powerhouse/spillway divider walls.

Advanced Turbines

Installation of new turbines at Priest Rapids Dam will be considered as part of a longer term replacement schedule, currently anticipated to begin in about 2017. Similar to the situation at Wanapum Dam, new turbines at Priest Rapids Dam would also increase hydraulic capacity from 174 kcfs at 68 feet of net head and at the cavitation limit to approximately 185 kcfs.

Flow Deflectors

Spillway flow deflectors have been installed at many dams. These devices are built into existing spillbays and prevent flow from plunging deep into the spillway stilling basin, tending to force higher energy flow out into the tailrace channel, and reducing the initial uptake in TDG. These structures also promote a rapid decrease in TDG by extending the boundaries of a more turbulent aerated plume. Near-field tests have shown that a significant and rapid decrease in TDG occurs within the aerated plume exiting the spillway's stilling basin due to flow deflectors.

Installation of flow deflectors on spillbays where they do not currently exist, and where it is thought to be beneficial, is being considered as a viable method for reducing TDG on some mid-Columbia River dams. In addition, modifications to existing flow deflectors may also help to

lower TDG. These modifications may include changing the height, length or the transition of the structure.

Additional Spillway Bays

Building additional spillway bays at existing dams to allow voluntary and involuntary spill releases to be more spread out, with less energy dissipation requirements and associated gas uptake, was determined to be a feasible alternative from the DGAS study. By creating more spillbays, the spill release per spillbay could be effectively reduced, directly correlating to reduced TDG production. Although this option has been considered viable for TDG reduction, it is a very expensive alternative.

Modification to Existing Unused Structures

Dams built with unused turbine capacity in anticipation of future turbine units may be able to modify these structures to pass water without entraining air. Additional capacity to spill without entraining air may be gained by redesigning or changing operations of existing spill gates. Other dam structures have been considered to pass water around or through dams without entraining air.

Powerhouse/Spillway Divider Walls

Additional improvements in TDG can be gained by construction of powerhouse/spillway divider walls. Depending on spill and powerhouse discharge flow dynamics, a portion of the powerhouse water may be entrained in the spillway flow. This situation is thought to be exacerbated by flow deflectors. The powerhouse waters are then subject to nitrogen saturation through contact with the bubbles in the immediate spillway. A divider wall could prevent powerhouse water from being entrained in the spillway stilling basin and gassed up to the same levels as the water being spilled over the spillway. Additional investigation is required to increase understanding of this issue prior to pursuit of corrective actions. If the entrainment flows are reduced or prevented, then this water would be available for dilution of the gassed up spillway releases beyond the spillway flow zone.

Compliance with TDG Criteria

The occurrence of TDG values that exceed the standards has decreased over the years as operators manage flows and spills to minimize TDG. This trend should continue as more measures and structural improvements are implemented. This TMDL will be applicable during the peak flow season for all spills below 7Q10 river flood flow conditions, regardless of the cause of the spill.

Federal, tribal, and state laws and rules require attainment of water quality standards, and therefore the ultimate goal of this TMDL is to achieve attainment. Special criteria have been established in Washington for “voluntary” spills for fish passage, and this TMDL includes allocations for that situation.

Ecology has regulatory authority over the water pollution effects of the PUD and federal dam projects. Washington's regulatory authority comes through the *Federal Clean Water Act*, and the *Washington State Water Pollution Control Act*.

- Ecology is responsible for ensuring that water quality standards are met. Ecology is confident that the collaborative relationship with the dam operators toward reducing gas will continue and be enhanced through this TMDL and the FERC 401 Certification process.
- The Corps, the BOR, and the PUDs continue working through the ESA forums established to oversee and carry out the requirements of the BiOps.
- Special dissolved gas conditions exist in the Washington State Water Quality Standards for the Columbia River. Higher gas levels are allowed in these standards in order to provide water and to pass juvenile salmonids in spill and avoid the turbines in the Columbia River.
- The Confederated Tribes of the Colville Reservation are providing a waiver from the 110% criteria in order to promote the Grand Coulee/Chief Joseph spill swap.
- The dam owner must provide assurances that they are taking steps to reduce dissolved gasses in order to get an approval for this special condition from Ecology. The Corps and each PUD that anticipates spilling water to augment juvenile fish survival submit a gas abatement plan to Ecology for approval. Ecology's approval will include certain conditions. Monitoring, compliance schedules and reporting is required. This standard can be found in Washington State Water Quality Standards (old) 173-201A(060)(4); (new)173-201A-200(1)(f).

For a dam wholly within Washington's jurisdiction to be covered by the allocations for fish passage, Ecology must designate the fish passage period (beginning and ending dates) based on the recommendations of NOAA Fisheries and other decision-making bodies, and must approve the gas abatement plan for the dam. Spills in support of fish passage (such as for research or performance testing) can also be included by the fish passage load allocations with prior approval from Ecology and if applicable, the Colville Confederated Tribes.

A dam will occasionally receive water in its forebay that exceeds the 115% criterion during fish spill season. During the short term phase I time period, the spill for fish passage should be supported, and spilling to the levels established by the fisheries agencies that result in exceedances of the criterion in the next forebay will not constitute non-compliance.

Measuring Progress: An Interagency Management Process

Water Quality Teams

There are a number of workgroups or teams already in existence working on water quality issues including TDG: the NOAA Fisheries Forum Water Quality Team which addresses issues in implementing the BiOp and the Ad-hoc Water Quality Planning Team which developed the "Water Quality Plan for Total Dissolved Gas and Water Temperature in the Mainstem Columbia and Snake Rivers."

Members include the action agencies, the dam operators, the states and tribes, EPA, and others with interest in the water quality of the Mid-Columbia River and other reaches of the Columbia and Snake Rivers. Inclusion of all these parties will facilitate coordination of this implementation plan with activities required under the BiOp and other basin wide efforts. The activities of this workgroup are as follows:

- Monitor completion of required improvement actions and studies.
- Evaluate study results.
- Accept studies or ask for changes.
- Make recommendations on proceeding with actions based on study results.
- Make recommendations on whether actions are feasible based on study results.
- Measure progress through the development of an annual review of water quality measures

Transboundary Gas Group

The Transboundary Gas Group (TGG) was formed in April 1998 during an international conference attended by scientists, planners, and policy-makers from federal, state and provincial agencies, tribes and first nations, private industry, utility owners/operators, and public interest groups from Canada and the United States. The TGG was formed to help coordinate dissolved gas planning activities between Canada, the United States, tribes, first nations, and other organizations. The overall, long-term goal of the TGG is to:

“Reduce systemwide total dissolved gas to levels safe for all aquatic life in the most cost-effective manner possible”

A steering committee helps guide the efforts of the group and monitor its fulfillment of the TDG goals. Initially, four technically focused workgroups were formed to assist in the development of a framework plan. The four groups were:

1. Biological Effects and Research
2. Monitoring and Information Sharing
3. Modeling (Computer Simulations)
4. Operational and Structural Gas Abatement

The TGG continues to meet twice each year, usually in the early Spring and again in the Fall. The latest developments in dissolved gas monitoring, abatement methods, modeling, and biological effects are discussed at the meetings. The group has also offered opinions and guidance regarding dissolved gas questions that have arisen in the Pacific Northwest.

To date the TGG has developed a “Framework Plan for Coordinating Activities of the Columbia River Transboundary Gas Group” and offered Canadian energy entities, specifically Columbia Power Corporation and Tech-Cominco, letters endorsing structural and operational gas abatement initiatives. The letters have provided TGG comments regarding gas abating structural and operational measures to be pursued at Brilliant and Waneta projects on the Kootenay and Pend d’ Oreille Rivers, respectively. Through contractual support by the British Columbia Ministry of Environment, Lands, and Parks the TGG also produced a paper addressing the

international treaties affecting potential water quality actions and remediation, “Treaty Implications of Dissolved Gas Management in the Columbia River Basin.”

Adaptive Management

The process for reviewing the status of implementation of this TMDL will follow the timing and process for the review of the federal BiOp in 2010. This may need to be modified. A water quality team made up of representatives of tribes and federal and state agencies will evaluate appropriate TDG control activities for this TMDL. Based on these findings, further studies may be needed, and TDG reduction activities will be redirected or accelerated if needed.

In its simplest form the adaptive management concept provides a strategy for moving forward in a technical field while in the absence of total knowledge about the consequences of this action. Under these conditions adaptive management allows the selection of the best informed management route or strategy, establishing a thorough monitoring system designed to quickly and accurately inform the observer if the strategy is on track and working as intended. If the results indicate otherwise then mid-course corrections are taken to keep projects and results moving in the desired direction. Each course alteration is accompanied by a modified monitoring plan.

The water quality criteria for the protection of beneficial uses may change in the future. If these changes occur, the wasteload and load allocations may be adjusted if needed to satisfy the new criteria.

TDG Abatement Plans

The state of Washington requires the operators of each dam on the Columbia River that must spill for juvenile fish passage to obtain approval from the Washington Department of Ecology of a gas abatement plan in order to spill water over the dam to assist in the passage of juvenile salmonids downstream and thus potentially raise the total dissolved gas saturation level above 110%. This standard can be found in Washington State Water Quality Standards (old) 173-201A(060)(4); (new)173-201A-200(1)(f).

The plan commits the operator to continue to evaluate, refine, and implement gas abatement activities. If gas abatement efforts are determined by the agency to be sufficient for more than one year, the agency may approve the plan for up to five years. These plans must contain a schedule for taking all reasonable steps toward compliance by reducing total dissolved gas at the dams during operational fish spills and involuntary spills, and planning for structural solutions. The dam operator is expected to participate in and provide information to regional groups that address system-wide dissolved gas problems.

A report is submitted annually describing the results of physical and biological monitoring, and any changes, modifications, and additions to the gas abatement plan including:

- Compliance schedule changes regarding specific targets and dates for moving toward meeting water quality standards.

- Forebay and tailrace monitoring plans.
- Quality assurance plans.
- Physical modeling plans.
- Structural changes.
- Operational changes.
- Reduction in spill due to successes of alternative fish passage facilities.

401 Certification

The load allocations for the PUD dams on the mid Columbia River will be incorporated into the FERC 401 Certifications that accompany the relicensing of each dam. Other requirements and conditions that address TDG levels from operation of a dam may be included to provide reasonable assurance that the water quality standard will not be violated. Schedules of compliance may be included in the FERC 401 Certifications or through an independent state water quality administrative order that specify submittals of reports and updates toward progress in complying with the load allocations. Participation in a water quality team may be a condition of 401 Certifications. A reopener clause to address new information during the term of the license is included in the Certification. The expiration dates for current FERC licenses that are scheduled for 401 Certifications are as follows.

- | | |
|--|------|
| • Priest Rapids Project (includes Wanapum Dam) | 2005 |
| • Rocky Reach Project | 2006 |
| • Wells Project | 2012 |
| • Rock Island Project | 2028 |

The FERC 401 Certification for the Rock Island project will be requested to be reopened prior to 2027 if the project is not generally in compliance with its load allocations for TDG.

Monitoring Strategy

Short-term compliance and the effectiveness of operational implementation actions will be monitored at existing fixed monitoring station sites for both fish passage and non-fish passage allocations. The current fixed monitoring station system consists of a station at Boundary and tailrace and forebay monitoring stations at each mainstem mid-Columbia River dam and at key locations in some tributaries. While these stations do a credible job of reporting meaningful data, some at times may not be achieving desired sampling objectives (representing spill or average forebay conditions).

TDG is currently monitored at each dam. The plan of action for TDG monitoring can be found on the TMT website <http://www.nwd-wc.usace.army.mil/tmt/documents/wmp/>. This plan is produced annually in coordination with the Fish Passage Plan and provides greater detail for those who are interested. The details of the 2003 water-quality monitoring plan are in Appendix 4 of the annual Water Management Plan.

In general the water quality fixed monitoring stations are designed to provide information needed to control dissolved gas supersaturation in the river system on a real time basis, to determine how project releases affect downstream water quality, trend monitoring, and to provide data of known quality to enhance analytical and predictive capability of existing models/tools. The data collected also measures temperature, as that is an integral part of analysis for total dissolved gas. Since 1994, two different types of fixed water quality monitoring stations have been used. Forebay and tailrace monitors are maintained at each hydroproject and record water temperature and total gas pressure on an hourly interval during the fish passage season. This information is coupled with operational data and reported in near real time at <http://www.nwd-wc.usace.army.mil/tmt/wcd/tdg/months.html>. This information is often applied to spill management practices for the upstream project and is applied to water quality compliance monitoring as well. In general, the water quality sampling methodology at a dam involves determining conditions above the dam at the forebay monitoring station and below the dam in spillway releases at the tailwater fixed monitoring station. The project forebay monitors are intended to represent a mixed cross section in the river just upstream of the dam and can be a fair approximation of aquatic habitat conditions as defined by TDG and water temperature in that area of the pool. The tailwater instruments are located near the project and are ideally positioned in the spillway releases, downstream of aerated flow and prior to complete mixing with powerhouse releases. These sampling stations enable the determination of project operations impacts on water quality conditions in the Columbia River.

During Phase I of implementation the Water Quality Team will continue to choose these sites based on balancing Endangered Species Act and Clean Water Act objectives. During Phase II and when less dependent on spills to move juvenile fish, the goal will be to “tighten up” the monitoring locations and TDG objectives to allow compliance with load allocation at all locations in the compliance area downstream of the aerated zone. The default locations were established during preparation of the TMDL and based on available information at that time and are listed in Table A-3, below. The locations may be modified in the future through additional observations and studies. The edge of the aerated zone is that location downstream of the spill where bubbles from spill cease to surface and rapid degassing ceases. Based on detailed synoptic surveys, either the fixed monitoring stations can be moved to a location likely to measure spill water TDG levels, or methods can be developed to back-calculate TDG levels from forebay levels, powerhouse flows and spill volumes.

Monitoring of long-term compliance with load allocations and the effect of structural changes will include an evaluation of previous and future near-field transect studies at the compliance location (the end of the aerated zone below each dam). Statistical relationships may be developed between TDG levels at the continuous monitoring location and the compliance location that allow real-time and long-term trend evaluation of compliance.

Prior to the initiation of a load allocation monitoring survey, a quality assurance project plan, or equivalent, must be approved by Ecology. The project plan should address the safety and stability of the site to support monitoring equipment and activities when subject to the strong hydraulics below the dams. Due to these factors, it is possible that an alternate site may be needed. If so, some correlation to the load allocation compliance point will be necessary.

Table A-3: TMDL Compliance Area Upstream Boundaries

Project	Location
Upstream Boundary	Lake Roosevelt below Canadian Border
Spokane Arm Boundary	Lake Roosevelt below Little Falls Dam
Grand Coulee Dam tailrace	end of spillway
Chief Joseph Dam tailrace	2000 feet below end of spillway ¹
Wells Dam tailrace	2000 feet below end of spillway ²
Rocky Reach Dam tailrace	1600 feet below end of spillway ³
Rock Island Dam tailrace	2000 feet below end of spillway ⁴
Wanapum Dam tailrace	2000 feet below end of spillway ⁵
Priest Rapids Dam tailrace	1500 feet below end of spillway ⁶

¹ Schneider and Carroll, 1999

² Pickett, 2002

³ USACE, 2003a

⁴ Schneider and Carroll, 2000

⁵ USACE, 2001c

⁶ USACE, 2003b

Potential Funding Sources

Known funding sources include power generation revenues through BPA, as directed by the Northwest Power Planning Council and System Configuration Team and the U.S. Congress and public utility revenues.

Cultural Resources

During the collaborative process of developing TDG reduction measures, the group will recognize the cultural resources that could be impacted by the measures being considered to reduce TDG. As measures are evaluated for the costs, benefits, and impacts on other uses of the river, cultural resources, particularly those of the tribes in the region, will be considered. The tribes intend to be active participants in the implementation process and will provide the group with the necessary information about the impact of potential measures on tribal cultural resources.